Tracer sampling frequency influences estimates of young water fraction and streamwater transit time distribution

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Abstract

The streamwater transit time distribution (TTD) of a catchment is used to derive insights into the movement of precipitation water via various flow paths to the catchment's stream. Typically, TTDs are estimated by using the convolution integral to model a weekly tracer signal measured in streamflow. Another measure for the fast flow component of catchment water transport is the fraction of young water (Fyw) in streamflow that is younger than a certain threshold age, which also relies on tracer data. However, few studies used tracer data with a higher sampling frequency than weekly. To investigate the influence of the sampling frequency of tracer data on estimates of TTD and Fyw, we estimated both indicators for a humid, mesoscale catchment in Germany using tracer data of weekly and higher sampling frequency. We made use of a 1.5 year long time series of daily to sub-daily precipitation and streamwater isotope measurements, which were aggregated to create the weekly resolution data set. We found that a higher sampling frequency improved the stream isotope simulation compared to a weekly one (0.35 vs. 0.24 Nash-Sutcliffe Efficiency) and showed more pronounced short-term dynamics in the simulation result. The TTD based on the high temporal resolution data was considerably different from the weekly one with a shift towards faster transit times, while its corresponding mean transit time of water particles was approximately reduced by half (from 9.5 to 5 years). Similar to this, Fyw almost doubled when applying high resolution data compared to weekly one. Thus, the different approaches yield similar results and strongly support each other. This indicates that weekly isotope tracer data lack information about faster water transport mechanisms in the catchment. Thus, we conclude that a higher than weekly sampling frequency should be preferred when investigating a catchment's water transport characteristics. When comparing TTDs or Fyw of different catchments, the temporal resolution of the used datasets needs to be considered.